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CASE REPORT

A MULTIDISCIPLINARY APPROACH TO THE REHABILITATION OF A COLLEGIATE FOOTBALL PLAYER FOLLOWING ANKLE FRACTURE: A CASE REPORT

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ABSTRACT

Background and Purpose: Multiple rehabilitation factors including overall wellness need to be considered when an athlete returns to sport after an injury. The purpose of this case report is to describe a multidisciplinary approach for return to sport of a Division I collegiate football player following a traumatic ankle fracture requiring surgical repair. The assessment and treatment approach included the use of a performance-based physical therapy outcome measure, self-reported functional abilities, body composition assessments, and nutritional counseling.

Case Description: A 21 year-old running back fractured his lateral malleolus due to a mechanism of injury of excessive eversion with external rotation of the ankle. Surgical intervention included an open reduction internal fixation (ORIF) of the fibula and syndesmosis. In addition to six months of rehabilitation, the patient received consultations from the team sports nutritionist specialist to provide dietary counseling and body composition testing. The Comprehensive High-level Activity Mobility Predictor-Sport (CHAMP-S), a performance-based outcome measure, self-report on the Foot and Ankle Disability Index (FADI-ADL, FADI-S), and body composition testing using whole body densitometry (BOD POD®), were administered throughout rehabilitation.

Outcomes: The subject was successfully rehabilitated, returned to his starting role, and subsequently was drafted by a National Football League (NFL) franchise. High-level mobility returned to above pre-injury values, achieving 105% of his preseason CHAMP-S score at discharge. Self-reported function on the FADI-ADL and FADI-Sport improved to 100% at discharge. Body fat percentages decreased (13.3% to 11.9%) and fat mass decreased (12.0 kg to 11.0kg). Lean body mass (78.1 kg to 81.5 kg) and lbm/in increased (1.14 kg/in to 1.19 kg/in). His BMI changed from 29.8 kg/m^2 to 30.6 kg/m^2.

Discussion: This case report illustrates the positive effects of a multidisciplinary approach where combining physical therapy and nutritional counseling demonstrated value with return to sport preparation and success following ankle fracture. A targeted physical therapy program combined with a personalized nutrition intervention based on body composition assessment assisted this athlete in avoiding deconditioning (atrophy, decreased aerobic capacities, and increases in body fat) often observed during postoperative care.

Level of Evidence: **5**

Key words: ankle fracture, American football, CHAMP-S, FADI, whole body densitometry

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BACKGROUND AND PURPOSE

Football has the highest injury prevalence of all collegiate sports.[1-3] In-game injuries occur far more frequently than in practice, with rates of 35.9 injuries per 1000 athletic-exposures as compared to 9.6 injuries per 1000 respectively.[2-3] Furthermore, more than 50% of injuries occurring in football, in either practice or game settings, occur in the lower limb.[2-3] Player contact is described as the most common mechanism for injuries in football, accounting for 78% of in-game injuries and between 57% (fall) and 69% (spring) of all practice injuries.[3]

High-level mobility is a required characteristic of sport performance at the elite (collegiate and professional) levels.[4] Mobility consists of the following physical performance factors: balance, postural stability, coordination, power, speed, and agility. Yet, the use of standardized outcome measures for high-level mobility is not the standard of care in return to sport considerations. For example, when deciding on return to sport in American Football, clinicians must consider the physical prerequisites for safe and successful restoration of function, including the components of high-level mobility.[4]

The ability to qualify and quantify changes in function are key in rehabilitation. A variety of methods exist to assess baseline function and ultimately to track progress over the course of time. Two of the most commonly used tools for assessing function include physical performance-based measures and patient self-report outcome measures (self-perception). Standardized outcome measures are currently used in the rehabilitation process to determine functional levels, predict mobility, determine the contribution of an intervention, assist with exercise prescription, measure change over time, and document services.[5] Outcome tools also allow clinicians and patients the ability to monitor and review progress in an objective manner, and may also serve as a means of motivation. Choosing the most appropriate measure is extremely important, taking the medical condition, and short-term and long-term goals into consideration. Additionally, the validity, reliability, testing environment, and ease of use, should all be strongly considered. In general, outcome tools can be classified as assessing impairments, body function (physiologic and/or neuromuscular function), activity (execution of a task of function), participation (involvement with life situation), and environmental factors (physical, social, attitudinal).

Prognostic indicators related to body composition and injury risk have been identified in the literature.[6-8] High body fat percentage (%fat) and higher body mass index (BMI) have both been associated with an increased risk of injury in competitive athletes. More specifically, body fat % and BMI have been highly correlated to an elevated risk of lower limb injury.[7-8]

A relationship between athletic performance enhancement and nutritional intake and body composition has been reported.[9] The dietary habits of consuming proportionally higher intakes of processed and refined foods, saturated fats, and lower intakes of fresh fruits and vegetables, are prevalent across the general populous, including athletes. Such diets contribute to overall poor health and can impair athletic performance.[9] Ideal body composition varies by athlete but in general, the less fat mass, the greater the performance potential.[9] Measurements of body composition are valuable tools when determining appropriate nutritional intake, since there is a direct relationship between dietary intake and body composition.[9] Excessive levels of body fat (%) can indicate poorer levels of conditioning and athletic performance or unbalanced dietary consumption.[9]

The purpose of this case report is to describe a multidisciplinary approach for return to sport of a Division I collegiate football player following a traumatic ankle fracture requiring surgical repair. The objective measures tracked in this case included high-level mobility, self-reported function, and body composition.

CASE DESCRIPTION: PATIENT HISTORY AND SYSTEMS REVIEW

A 21-year-old male Division I collegiate football player sustained a distal fibula fracture, subluxation of the talus, and a tear to the deltoid ligament while running with the ball late in a game. While being tackled in a crouched position, his upper body rolled posteriorly over a planted and externally rotated right foot, causing a traumatic eversion and external

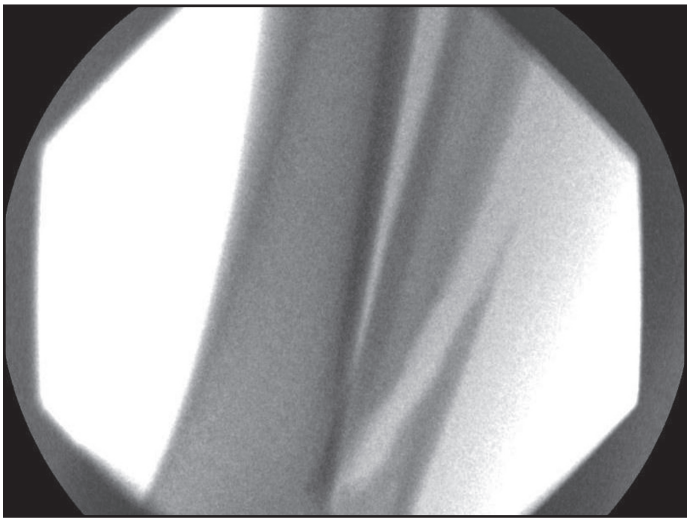

Figure 1. *Radiograph showing distal oblique fracture of the fibula.*

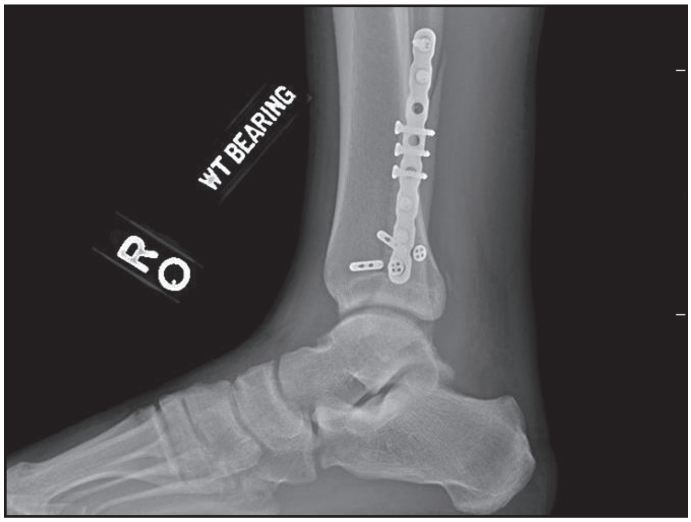

Figure 2. *Lateral view radiograph in weight bearing, of the post-surgical ankle.*

rotation force to the ankle, resulting in a fracture to the distal fibula. He was immediately removed from the game and the ankle was placed in a short leg immobilization boot. He had no prior significant medical history.

Radiographs confirmed an oblique and slightly displaced fracture to the distal fibula (Figure 1). The orthopaedic surgeon decided that an open reduction with internal fixation was necessary and surgery was performed two days following the injury. An 8-cm lateral incision was made over the fibular fracture site and the superficial fibular nerve was identified and protected. Three lag screws were placed through the fracture site, with 3.5 cortical screws to lag the fracture site. An Arthrex neutralization plate was put into place to provide additional stability. Three more cortical screws were placed proximally and two screws were placed distally to the fracture site. The syndesmosis between the tibia and fibula was widened, thus two Arthrex Tight Rope fixations were inserted to stabilize the syndesmosis (Figure 2). The subject was placed in an ankle orthosis following surgery. There were no surgical complications.

At the time of his initial physical therapy evaluation, the subject was informed that the data concerning his case would be submitted for publication. The subject's confidentiality was protected according to the U.S. Health Insurance Portability and Accountability Act (HIPPA) and IRB approval for this case report was granted. The subject participated in a sport-specific physical therapy program in the athletic training facility after discharge from the hospital.

The subject's postoperative presentation was unremarkable for complications and he was able to participate in daily rehabilitation sessions under the supervision of the physical therapist and athletic trainer. The subject progressed through the treatment protocol within surgical precautions accounting for his stated goals of returning to sport, and at the same time adding lean body mass prior to the commencement of the upcoming season. The subject was examined and monitored over the course of his rehabilitation by a multidisciplinary team, which included an orthopaedic surgeon, physical therapist, athletic trainers, and an exercise physiologist who serves as a sports nutrition specialist for all university varsity teams.

CLINICAL IMPRESSION #1

When considering an appropriate physical performance-based measure for return to sport it is essential to analyze the participant's position-related needs. The position of running back necessitates multidirectional movements that stress the body's ability to accelerate, decelerate, pivot, and transition with remarkable force and speed. Running backs are also involved with plays that vary in distance, and thus need to have appropriate aerobic and anaerobic capacities.

Considerations for successful rehabilitation of distal fibular fractures includes careful progressions through weight-bearing activities, gradually

increasing physiologic responses to exercise, and limiting pain-inducing or exacerbating activities (Table 1). Therefore, successful rehabilitation was defined for this subject by the following measures: 1) attaining functional range of motion, joint mobility, and strength 2) achieving pre-injury baseline scores on the Comprehensive High-Level Activity Mobility Predictor-Sport (CHAMP-S), and 3) self-reported full functional abilities on the FADI-ADL and FADI-Sport. The intervals for completing the functional outcome measure and self-report were based on periods of transitions between phases of rehabilitation.

EXAMINATION

The Comprehensive High-Level Activity Mobility Predictor (CHAMP) is a reliable, valid, and responsive performance-based outcome measure of high-level mobility that was developed in order to assess readiness to return to high-level activity and return to duty for service members and veterans with traumatic lower limb loss.[10-11] The four tests that make up the CHAMP are: Single Limb Stance (SLS), Edgren Side Step Test (ESST), T-Test, and the Illinois Agility Test (IAT). The CHAMP has been adapted to the CHAMP-S, specifically for the athletic population, by modifications made to two of the CHAMP items.[12] Modifications were made to the ESST and T-Test. The ESST was revised (mESST) in order to enhance the ease of administration and scoring. The units of measurements changed from meters to seconds and they were required to complete three full right-to-left passes (8 m per pass for a total of 24 meters). The T-Test was changed to an L-Test without any changes to the total length of the course (10 m by 10 m). The total time of completion of the L-Test is recorded. The 0-20 point scoring system was also modified from the CHAMP for the athletic population (CHAMP-S), in order to be responsive to change for the higher levels of mobility performance. The scores for each individual test are added together to produce a composite CHAMP-S score, ranging from 0-80, with 80 representing the highest level of performance. The CHAMP-S has been found to have excellent inter-rater reliability when administered to uninjured Division I collegiate football players.[12]

The Foot and Ankle Disability Index (FADI) ADL and Sports subscales were used to assess self-reported functional limitations. The FADI-Sport (FADI-S), a subset of the FADI, assesses limitations in higher functioning athletes with activities that are specific to sport.[13] The FADI-ADL contains 26 items and the FADI-S contains eight items, with each scored from 0 (unable to do) to 4 (no difficulty at all). The 4 pain items of the FADI-ADL are scored 0 (none) to 4 (unbearable). The FADI-ADL has a total point value of 104 points, whereas the FADI-S has a total point value of 32. The FADI-ADL and FADI-S are scored separately as percentages, with 100% representing no self-reported dysfunction.[14] Both the FADI-ADL and FADI-S have been found to be the most appropriate evaluative instruments to quantify functional disabilities in athletes with chronic ankle instability (CAI).[13-20] The FADI-ADL and FADI-S have been found to be reliable and valid in assessing progress during rehabilitation in patients with CAI when used at one-week and six-week intervals between administration.[13-20]

The current gold standard for measuring body composition is hydrostatic weighing.[9,21-22] However, this method is time consuming and requires a great amount of technical expertise. As of the mid 1990's another technique known as air-displacement plethsmyography (ADP) has been widely accepted as valid, reliable and much easier to implement.[9,21-22] A commercial device known as the BOD POD® (Life Measurement Instruments, Concord, CA) utilizes ADP, which is more accurate than BMI in estimating body composition in male athletes, as BMI typically grossly overestimates body fat in athletes.[23]

The BOD POD® is used to estimate the fat and fat-free mass percentages. The BOD POD® uses ADP to assess body volume and estimate %fat.[24] ADP estimates body density by deriving body volume and measuring body mass. The Bod Pod® then calculates %fat from body density estimates using equations proposed by Siri and Brozek and colleagues.[24] The results can then be used to calculate body density using the mass/volume ratio.[25] The BOD POD® is a reliable and valid tool when assessing %fat in both male and female participants.[9,24-27] Although there is strong test-retest reliability for %fat assessment using the BOD POD®, %fat scores have been found to be slightly lower than values for hydrostatic weighing (HW), dual-energy X-ray absorptiometry (DXA),

Table 1. *Post-operative rehabilitation protocol*

Rehabilitation Protocol (Protection, Functional Progression, Sport-Specific, Supervised Sport Activities)				
	Goals	**Precautions/ Contraindications**	**Suggested Exercises**	**Physical Performance Measures**
Phase I	- Protect fixation - Initiate early motion - Prevent stiffness and loss of bone density - Promote cartilage health, decrease pain, edema, inflammation - Decrease muscle atrophy - Educate patient and family if needed	- WBAT 6-8 weeks; crutches for ambulation - Manage wound - Foot must be kept in neutral for 1-2 weeks - Assess for DVT - Avoid painful activities that would create an inflammatory response	Aerobic Conditioning - Upper body ergometer Modalities - Cryotherapy - Edema and pain control through electrical stimulation (TENS, microcurrent, high-volt) ROM - Ankle PROM → AAROM → AROM - Static stretching - Ankle pumps - Towel stretches - Ankle alphabet Strength - Manual resistance at thigh and hip in all planes - Intrinsic toe flexion - Ankle isometrics in all planes - Proximal Hip PNF D1/D2 Balance - Weight shifting in all planes	- FADI-ADL - FADI-Sport
Phase II	- Restore talocrural and subtalar ROM (~80%) and >4/5 strength - Maintain or improve strength of lower extremity and core musculature - Control edema - Maintain optimal bone and soft tissue healing environment - Increase proprioception, balance, coordination - Single-limb balance (≥30 seconds)	- WBAT to FWB dependent on pain and ROM, as well as fixation and callous formation - Peroneal tendinitis due to hardware - Nonunion - Hardware failure - Posttraumatic arthritis - Compartment syndrome	Aerobic Conditioning - Stationary bike → Elliptical → Stairclimber Modalities - As needed ROM - Ankle PNF stretching in all planes - Foam rolling program - Scar mobilizations Strength - Open chain isotonics for the lower limb - Manual resistance to the ankle, knee, hip - Lower limb PNF strengthening D1/D2 - Seated and standing isotonic calf raises - Squats progression - Lunge progression - Core stabilization	- FADI-ADL - FADI-Sport - CHAMP-S

Table 1. *Post-operative rehabilitation protocol (continued)*

			Proprioception, Coordination, Balance - Addressing movement impairments as noted through CHAMP-S testing - Double → Single Limb balance progressions - Gait training - Ankle neutral → inversion → eversion closed chain progressions - Star excursion balance exercises - Ankle, hip, and step strategy training - Low-level multiplanar agility maneuvers	
Phase III	- Return to football-specific training - Self-report on FADI-ADL and FADI-Sport at 100% - Achieve 90% of baseline CHAMP-S score	- Abnormal pain, swelling, edema, lack of posterior tibial artery pulse - Hardware failure - Posttraumatic arthritis - Compartment syndrome - Peroneal tendinitis	Aerobic Conditioning - Alter G treadmill - Hydroworx treadmill - Jog → Run Progression ROM - Self-stretching Strength - Continued squat progression - Continued lunge progression - Plyometric progression - Proprioception, Coordination, Balance - Addressing movement impairments as noted through CHAMP-S testing - Programmed → Reactive coordination drills - Agility training (ladders, dot drill, cutting, shuttle)	- FADI-ADL - FADI-Sport - CHAMP-S
Phase IV	Return to premorbid participation avoiding the "overdo" complex; full return to sport	- Abnormal pain, swelling, edema, lack of posterior tibial artery pulse - Hardware failure - Posttraumatic arthritis - Compartment syndrome	Aerobic Conditioning - Football-related ROM - Maintenance of dorsiflexion mobility Strength - Return to team lifting Proprioception, Coordination, Balance - Maintenance of single limb stance balance	As needed

DVT= Deep vein thrombosis, TENS= Transcutaneous electrical nerve stimulation, AROM= Active range of motion, AAROM= Active-assistive range of motion, PROM= Passive range of motion, WBAT= weight bearing as tolerated, FWB= full weight bearing, FADI-ADL= Foot and Ankle Disability Index-Activities of Daily Living, FADI-S= Foot and Ankle Disability Index-Sport, CHAMP-S= Comprehensive High-level Activity Mobility Predictor-Sport, PNF= Proprioceptive neuromuscular facilitation

and three compartment modeling (3C).[21] The technical error of measurement for the BOD POD® was lower, with a value of 0.40%, than those reported for HW (0.42%) and skinfold measures (0.61%).[9]

CLINICAL IMPRESSION #2

Due to the nature of the subject's initial non-weight bearing status and its potential impact on disuse atrophy and overall decreased abilities for aerobic conditioning, the treating physical therapist believed nutritional counseling would have a positive impact in the early phases of his recovery. In addition, the subject's stated goal of gaining lean body mass and increasing his total body weight needed to be initially measured and monitored during his post-operative care. The subject had a history of poor eating habits, which he expressed to the nutritional counselor at the time of his first consult. Therefore, the team sports nutrition specialist was included to both counsel the subject on his diet and also track changes in body composition using the BOD POD®.

INTERVENTION

A four-phased rehabilitation program began one day after surgery. The phases were divided into: protection (I), functional progression (II), sport-specific (III), and supervised sport activities (IV).

Protection (Phase I): The protection phase began with a non-weight bearing protocol to allow for proper fixation and soft-tissue healing. After one month, the subject was transitioned to toe-touch weight bearing after radiographs showed soft callous healing. Rehabilitative goals at this time were to protect the post-operative ankle, eliminate effusion, restore adequate range of motion, and mitigate weakness caused by arthrogenic muscle inhibition. These goals were achieved by controlling ankle joint swelling and pain, regaining appropriate voluntary contraction of the leg musculature, initiating immediate knee and hip motion, and educating the subject on minimizing the time spent with the ankle in a dependent position by adequately elevating his limb.

Functional Progression (Phase II): The rehabilitation goals for the functional progression phase were to achieve full active ankle range of motion, gain trunk and lower extremity strength (>4/5 MMT), initiate generalized aerobic conditioning, normalized gait, single-limb balance (≥30 seconds) with postural steadiness, and uncompensated pain-free mobility. During this phase, careful progressions were initiated to begin stressing the ligamentous complexes about the ankle. This was done by advancing closed kinetic chain exercises while ankle pre-positioning the ankle from a neutral to inversion and ultimately eversion posture. CHAMP-S testing was initiated during this phase to allow the physical therapist and athletic trainers to develop an exercise-based intervention targeting any balance and/or mobility deficiencies noted.

Sport-Specific Phase (Phase III): At four months post-op, the subject was cleared to begin participating in position-specific agility drills and weight room workouts with the team. Goals for the subject during this phase included a return to football-specific training, self-report scores on FADI-ADL and FADI-Sport of 100%, and to achieve 90% of his pre-season CHAMP-S score.

The plan of care began shifting to football-specific activities, with interventions focusing on normalizing limb function and lower-quarter strength, movements incorporating skill, lower extremity stability, and agility drills. Higher-level impact training was initiated in the pool, and ultimately transitioned to dynamic surfaces.

Supervised Sport Activities (Phase IV): The goals for the subject during this phase were a return to pre-morbid participation levels. During this phase, the subject was able to perform independent stretching and strengthening exercises, participate in a structured aerobic and sport-specific condition, and partake in self-relaxation activities. Full return to sport was gradually incorporated in returning to supervised sport-specific activities with his coaches. At the six-month mark, he was cleared for all activities.

The CHAMP-S was used to assess high-level mobility over the course of his rehabilitation and assist with determining readiness to return to sport. The CHAMP-S provides insight into rehabilitation factors: 1) early success in single-limb stance cleared the subject for progressions in therapy**;** 2) assistance with identifying limitations in movement in different planes of motion that are of immediate concern to better customize plan of care; and 3) integrates the

subject into the rehabilitation process by providing him or her with immediate performance feedback which could improve confidence and motivation in sport-specific agility movements. Asymmetries in movement and slower test interval times relative to his pre-season scores were evaluated for causative factors, including strength and flexibility testing of the muscle groups involved with movement in that plane, neuromuscular control (balance, coordination, and power), muscle activation, and postural factors.

The goal for the subject of this study was to achieve ± 5 % from his original preseason, preoperative, baseline composite CHAMP-S scores. The CHAMP-S was initiated once the subject was allowed to ambulate without an assistive device and was administered at least once per phase of rehabilitation, with progressions from brisk walking in the earlier phases to ultimately maximal exertion. It was hypothesized that the subject would improve his overall score as he progressed through rehabilitation.

The BOD POD® was used to estimate the fat and fat-free mass percentages at two distinct points in his rehabilitation. All testing was performed in accordance with the manufacturer's instructions. Testing on the Bod Pod® is convenient and minimally burdensome. The testing protocol requires sitting in the Bod Pod®, breathing through a tube, and providing three short bursts of exhalations. The subject was to undergo his consult with the team nutritionist shortly after surgery. The plan was for the sports nutrition specialist to counsel the subject on both caloric intake guidelines and on dietary recommendations. Lower caloric intake recommendations were important to coincide with lower caloric expenditure, especially during the earlier phases of rehabilitation. As the subject began to progress with higher activity demands during the later phases of rehabilitation, higher caloric intake levels were recommended. The goal was for body composition measurement to match his dietary consumption, assuming he remained compliant with his nutritional plan.

Caloric intake prescription for the subject was calculated using his goal-weight for the upcoming season and current levels of energy expenditures. Caloric recommendations were then made to address improving lean body mass (LBM) over the course of his recovery. LBM is defined as the weight of fat-free mass (bone, water, muscle, vasculature, connective tissue) and is measured in either pounds or kilograms. LBM is the primary contributor to resting energy expenditure as well as overall caloric expenditure, therefore, this method of calculating caloric intake needs is individualized for body composition goals.[28] Given the physiological requirements of football, the nutritionist recommended a nutrition plan with energy requirements based on LBM consisting of 60% carbohydrate, 20% protein and 20% fat.[29] This macronutrient ratio is within the standards of optimum performance for football.[30] Previous research has shown that dietary modifications have a positive effect on body composition.[31]

Prior to injury, the subject's caloric needs were estimated at 4340 kcal/day. Postoperatively, it was recommended that he reduced his caloric intake to 3514 kcal/day to accommodate the significant reduction in energy expenditure during the early phases of rehabilitation. The macronutrient recommendation stayed relatively unchanged; however, the subject was counseled to reduce intake of simple sugars, specifically beverages, and processed carbohydrates, while increasing his intake of fruits and vegetables. As the subject progressed through rehabilitation, and as both exercise intensity and energy expenditures increased, adjustments to the caloric intake recommendations were made accordingly. Once he was cleared to begin full football activities, he was re-assessed with the BOD POD® and a recommendation to increase his caloric intake to 4416 kcal/day was made.

OUTCOME

As part of standard of care, range of motion (ROM) measurements and manual muscle testing (MMT) were administered throughout the rehabilitation process. ROM and MMT were symmetric bilaterally at the time of discharge from rehabilitative care. A timeline summary of relevant events can be found in Table 2.

At eight months postoperative, the subject was able to improve on his preseason performance by demonstrating an increase in his CHAMP-S score of 5% when compared to baseline score (60 to 63). He was able to maintain SLS for 30 seconds two months

Table 2. *Timeline of events*

Week	Relevant Events
Week 0	• Occurrence of Injury • Hospitalization • Surgical Intervention: ORIF fibula and syndesmosis • Non-weight bearing on lower extremity with crutches
Week 2	• Sutures removed and steri-strips applied • Radiograph shows maintained alignment of fracture site • Short leg cast applied • Continuation of non-weight bearing on the lower extremity
Week 5	• Radiographs demonstrate normal healing with no osseous abnormalities • Advance to toe touch weight bearing on the lower extremity
Week 9	• Incisions fully healed without infection • Radiographs show interval fracture healing well with reduced joint line and no osseous abnormalities • Residual fracture line at proximal portion of fibula fracture • Cleared to begin light strengthening and balance • Walking boot use discontinued
Week 14	• Began Alter-G running at 60% of BW • Residual fracture line at proximal portion of fibula fracture shows interval healing when compared with previous radiographs
Week 18	• Patient began sport specific functional exercises/drills

postoperatively and maintained this performance at all testing sessions. The mESST improved 74.2% from a score of 8 at two months to a score of 15 at eight months. The subject also improved in the L-Test by 71.7%, from a score of 5 at two months to a score of 13 at eight months. An interesting finding provided by the CHAMP-S was that the subject consistently exhibited faster times with left lateral agility (i.e., side-stepping towards the left with his right surgically repaired limb acting as the trailing/propelling limb) as compared to right lateral agility at baseline and throughout the rehabilitation process. The subject improved in the IAT by 70.7%, from a score of 6 at two months to a score of 15 at eight months (Table 3).

The subject scored 100% on the FADI-ADL and FADI-S at five months after surgery, suggesting the subject perceived he had fully recovered. The FADI-S is unique in that it is a population-specific subscale designed for athletes.[13] Many subjective reports of function are designed to be used among older populations or populations with limitations in the performance of activities of daily living.[13] When such scales are used in athletic populations, a ceiling effect may be observed: athletes score at the extreme high end of normal function. This, in turn, decreases the sensitivity of the scale to functional deficits and treatment effects. Therefore, the subject's scoring at the highest level is of clinical significance.

Changes in %fat and LBM, as measured by the BOD POD®, were found over the two testing periods. There was a decrease in %fat from 13.3% to 11.9% (-1.4%) and LBM increased from an immediate post-injury value of 78.1 kg to 81.5 kg (+ 3.4 kg) at six months. During rehabilitation, his total mass increased from 90.1 kg to 92.5 kg (+2.4 kg). The subject also gained 4.99 kg of total body weight prior to the start of the following season (Table 4).

DISCUSSION

Elite football players are susceptible to ankle injuries due to high rotational and large impact forces placed on the ankle during running, cutting, and tackling.[32-36] It has been reported that 72% of players that presented to the 2006 NFL Combine had a

Table 3. *CHAMP-S scores: Baseline and post-operative*

Date			Date		Date		Date	
Baseline			2 Months		4 Months		8 Months	
SLS	**Best Time(s)**	**Score**	**Best Time(s)**	**Score**	**Best Time (s)**	**Score**	**Best Time**	**Score**
Left	30		30		30		30	
Right	30	20	30	20	30	20	30	20
mESST	8.38	14	10.85	8	9.64	11	8.05	15
L-Test								
Forward	2.47		3.46		2.53		2.41	
Right SS	2.40		3.45		2.79		2.56	
Left SS	2.86		4.08		3.04		2.81	
Backward	2.98		3.88		2.98		2.88	
Total Time	10.71	12	14.87	5	11.34	11	10.66	13
IAT								
T + COD	5.88		7.63		6.11		5.05	
Weave	5.52		7.26		6.32		5.31	
COD	4.99		6.81		5.03		4.99	
Total Time	16.39	14	21.70	6	17.46		15.35	15
Total CHAMP-S Score		60		39 (65%)*		53 (88%)*		63 (105%)*
Comments:								

Abbreviations: SLS= Single Limb Stance; mESST= Modified Edgren Side Step Test; IAT= Illinois Agility Test; SS= Side Step; T+COD= Transfer to Standing + Change of Direction; COD= Change of Direction
CHAMP-S Item Scores = 0 – 20; Total CHAMP-S Score Range: 0-80
*Percentage of baseline

Table 4. *Body composition changes*

Post-Operative Week	Weight (kg)	Body Fat %	Lean Body Mass (LBM) (kg)	Fat Body Mass (kg)	Height (in)	LBM/In (kg/in)	BMI
Preseason	87.7	6.5	82.1	5.71	68.5	1.20	29.1
8	90.1	13.3	78.1	11.9	68.5	1.14	29.8
20	92.5	11.9	81.5	11.0	68.5	1.19	30.6

history of foot and ankle injury.[32] It has been speculated that the skill-position players (running backs and wide receivers) have an increased risk of lower extremity injury because of the amount of rotational forces associated with cutting and agility maneuvers.[32] Several authors have supported this assertion, stating that the running back position in particular is at an increased injury risk.[32-33] Data gathered at the 2006 NFL combine found that running backs had the highest percentage of foot and ankle surgeries upon presentation compared to all other positions.[32]

Surgical reduction and rigid internal fixation at the fracture site reduces the probability of a future dis-

placement.[37] Furthermore, internal fixation provides the joint with an increased ability to withstand early weight bearing and ankle motion, thus allowing rehabilitation only a few days following surgery.[37] Authors have also found quicker improvements in return to ADLs and work, in subjects that underwent early functional exercise and weight-bearing following internal fixation of the ankle. [37-38]

The CHAMP-S was successfully used as a performance-based outcome measure of high-level mobility to determine the subject's current function, change in function throughout the rehabilitation process and to determine readiness to return back to sport safely. The goal of returning the subject to +/- 5% was the result of a pilot study conducted that looked to establish the CHAMP-S as a measure of return to sport following lower limb injury in Division I collegiate student-athletes. The results of the study found that the 10 student-athletes who returned to sport safely following a lower limb injury, and did not sustain a re-injury to the ipsilateral or contralateral limb, achieved a mean return to sport CHAMP-S score of 103% +/- 5% with a range from (95 - 109%). A major benefit of the CHAMP-S test is that it allowed the rehabilitation team to assess mobility once the subject was able to ambulate with his full body weight. Other commonly used functional tests (i.e. hop test, jump test, etc.) cannot be performed in the earlier rehabilitative phases due to the higher levels of impact on the involved limb. In addition, as the subject progressed in exercise intensity and began to perform bi-planar, and multi-planar movements, the rehabilitation team was able to identify limitations in mobility, allowing for targeted prescriptive exercises to address his limitations.

Generally, measurements of strength, ROM, and functional tests are the standard criteria for assessment of an athlete's progression through rehabilitation.[39-41] More specifically the Limb Symmetry Index (LSI) is frequently used as a measure of function, comparing either distance or time of the involved to the uninvolved limb when performing a single-limb task (single leg hop testing). However, as with many other return to sport assessments, there are noted limitations with the LSI. The primary issue is the utilization of the uninvolved limb as a standard of optimal function. The LSI uses relative, comparative data that neglects the influence of past injury or other limitations that currently affect the uninvolved limb in both strength and function. Though having pre-injury data to compare with post-injury results could serve to minimize such limitations.[39,42-44] Isokinetic testing that is used to determine strength of the involved limb using LSI can also fail to account for these limitations of uninvolved leg and, like hop testing, is prohibited in early phases of rehabilitation following many lower extremity injuries.[39,45] Additionally, other studies have shown poor correlation of LSI scores with self-reported knee function as well as inconsistent results under fatigued conditions.

Verstegen et al[46] also emphasized that sports involve multidirectional movements, stressing the body's ability to decelerate, pivot, and transition with remarkable force and speed. Thus, there is a need for an outcome measure to assess all these movement variables in multiple planes of motion throughout the continuum of rehabilitation, starting in the early postoperative phases and continuing through to return to sport activities. This type of outcome measure can help objectify return to play considerations, while increasing player confidence that the risk of re-injury may be minimized.[39,41,46-47]

Self-reported function was tracked using the FADI-ADL and FADI-S scales. The FADI-S has been shown to be reliable in detecting functional limitations in subjects with chronic ankle instability and is sensitive to differences between healthy subjects and subjects with CAI.[13] The FADI-ADL and FADI-S are also sensitive to improvements in function after rehabilitation in subjects with CAI. Since CAI is a condition that specifically hinders rigorous and athletic activity without affecting low-level task, the FADI-ADL and FADI-S were deemed an appropriate self-report outcome instrument for this case.[16]

The subject in this case report attained full scores on both the physical performance-based and self-report measurements. It should be noted that several authors have compared the level of agreement between performance-based measures and self-report.[48-50] Shulman et al[48] found low to moderate agreement between measures, with a moderate correlation (r =.48) between patient's self-reported difficulty in performing tasks and observer assessment. After

the patients actually performed the tasks, the correlation increased (r = .78). The authors concluded a mismatch may exist between how patients believe they function and how they actually function.[48] Similar results were found in patients undergoing total knee arthroplasty, where important limitations in knee function and performance deficits were unrecognized by self-report outcome measures.[49-50] Therefore, clinicians and researchers should consider supplementing self-report with performance-based measures.

Body composition is an important factor to consider throughout the rehabilitation process. Higher BMI, as a result of higher relative body weights, has been shown to increase the risk of injury in male military recruits, due to the higher compressive forces during activities such as running, walking and marching, specifically in overuse injuries.[51] However categorizing athletes using BMI may disproportionately misclassify them as overweight or obese due to their more muscular physiques and higher bone mineral density values when compared to sedentary individuals. Therefore, the use of body composition measures, such as LBM, in an athletic population could present an opportunity for future studies. In a study of Gaelic football players, Watson demonstrated that a higher preseason LBM value correlated with a lower risk of injury during the season.[52] Alternatively, those players who had a reduction in LBM from preseason to mid-season, suffered an increase in the rate of injuries.[52] In this case report, the subject had an increase in LBM, total body weight, and BMI, and a decrease in %fat. Of note, the subject did play the entire following season without missing any playing time due to injury.

Despite the wide spread practice of using %fat and BMI tracking in both determining and monitoring goal-weights in amateur and professional athletes, there are no published studies that incorporate these measures in tracking body composition changes throughout the course of rehabilitation. It is considered general knowledge that athletes undergo degrees of deconditioning following injury, immobilization, and surgery, specifically as it relates to increases in fat. However, it is not common physical therapy practice to refer to other allied health professionals to measure body composition during rehabilitation.

CONCLUSION

The results of this case report demonstrate that it is possible to safely return to sports following a surgically repaired traumatic ankle fracture while, concurrently, improving high-level mobility, self-reported function, and body composition. The subject was successfully rehabilitated, returned to his starting role, and was subsequently drafted by a National Football League franchise. Sport-specific rehabilitation, body composition testing, and nutritional education with dietary counseling were key components in this process. Adjusting nutritional consumption and monitoring body composition in order to increase lean muscle mass and total mass while decreasing fat mass is possible while concurrently improving high-level mobility, as measured by the CHAMP-S. Clinicians should consider a similar multidisciplinary approach to enhance outcomes and performance for their injured athletes.

REFERENCES

1. Hame SL, LaFemina JM, McAllister DR, et al. Fractures in the collegiate athlete. *Am J Sports Med.* 2004;32:446-451.
2. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: Summary and recommendations for injury prevention initiatives. *J Athl Train.* 2007;42:311-319.
3. Dick R, Ferrara MS, Agel J, et al. Descriptive epidemiology of collegiate men's football injuries: National Collegiate Athletic Association injury surveillance system, 1988-1989 through 2003-2004. *J Athl Train.* 2007;42:221-233.
4. Garstecki MA, Latin RW, Cuppett MM. Comparison of selected physical fitness and performance variables between NCAA Division I and II football players. *J Strength Cond Res*. 2004;18(2):292-297.
5. Gaunaurd IA, Gailey RS, Pasquina PF. More than the final score: development, application, and future research of comprehensive high-level activity mobility predictor. *J Rehabil Res Dev*. 2013;50(7):vii-xiii.
6. Hagglund M, Walden M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *J Sports Med.* 2006;40:767-772.
7. Gomez JE, Ross SK, Calmbach WL, et al. Body fatness and increased injury rates in high school football linemen. *Clin J Sports Med.* 1998;8:115-120.
8. Dvorak J, Junge A, Chomiak J, et al. Risk Factor Analysis for Injuries in Football Players. *Am J Sports Med.* 2000;28:69-74.

9. Collins MA, Millard-Stafford ML, Sparling PB, et al. Evaluation of the BOD POD for assessing body fat in collegiate football players. *Med Sci Sports Exerc.* 1999;31:1350-1356.
10. Gailey R, Scoville C, Gaunaurd I, et al. Construct validity of Comprehensive High-Level Activity Mobility Predictor (CHAMP) for male servicemembers with traumatic lower- limb loss. *J Rehabil Res Dev*. 2013;50:919-930.
11. Gailey RS, Gaunaurd IA, Raya MA, et al. Development and reliability testing of the Comprehensive High-Level Activity Mobility Predictor (CHAMP) in male service- members with traumatic lower-limb loss. *J Rehabil Res Dev*. 2013;50:905–918.
12. Gaunaurd IA, Gailey RS, Raya MA, et al. Establishing the reliability of the Comprehensive High-level Activity Mobility Predictor-Sport in collegiate football players using a mobile device application (SPL49). *J Orthop Sports Phys Ther.* 2014;44:A67.
13. Hale SA, Hertel J. Reliability and sensitivity of the Foot and Ankle Disability Index in subjects with chronic ankle instability. *J Athl Train*. 2005;40:35-40.
14. Eechaute C, Vaes P, Aerschot L, et al. The clinimetric qualities of patient-assessed instruments for measuring chronic ankle instability: a systematic review. *BMC Musculoskelet Disord.* 2007;8:6.
15. Naqvi G, Shafqat, Awan N, et al. Tightrope fixation of ankle syndesmosis injuries: Clinical outcome, complications, and technique modification. *Injury.* 2012;43:838-842.
16. Martin R, Irrgang J. A survey of self-reported outcome instruments for the foot and ankle. *J Orthop Sport Phys Ther.* 2007;37:72-84.
17. Martin RL, Burdett RG, Irrgang JJ. Development of the Foot and Ankle Disability Index (FADI) [abstract]. *J Orthop Sports Phys Ther.* 1999;29:A32–A33.
18. Hale S, Hertel J, Olmsted-Kramer L. The effect of a 4-week comprehensive rehabilitation program on postural control and lower extremity function in individuals with chronic ankle instability. *J Orthop Sports Phys Ther.* 2007;37:303-311.
19. Button G, Pinney S. A meta-analysis of outcome rating scales in foot and ankle surgery: Is there a valid, reliable, and responsive system? *Foot Ankle Intl.* 2004;25:521-550.
20. Carcia C, Martin R, Drounin J. Validity of the foot and ankle ability measure in athletes with chronic ankle instability. *J Athl Train.* 2008;43:179-183.
21. Fields DA, Goran MI, McCrory MA. Body-composition assessment via air-displacement plethysmography in adults and children: a review. *Am J Clin Nutr.* 2002;75:453-467.
22. Vescovi JD, Zimmerman SL, Miller WC, et al. Evaluation of the BOD POD for estimating percentage body fat in a heterogeneous group of adult humans. *Eur J Appl Physiol.* 2001;85:326-332.
23. Ode JJ, Pivarnik JM, Reeves MJ, et al. Body mass index as a predictor of percent fat in college athletes and nonathletes. *Med Sci Sports Exerc.* 2007;39: 403-409.
24. Bentzur KM, Kravitz L, Lockner DW. Evaluation of the BOD POD for estimating percent body fat in collegiate track and field female athletes: A comparison of four methods. *J Strength Cond.* 2008;22(6):1985-1991.
25. Mitchell C, Stafford M, Melinda L, et al. Evaluation of the Bod Pod for assessing body fat collegiate football players. *Med Sci Sports Exerc*. 1999;31:1350-1356.
26. Madallozzo G, Cardinal B, Snow C. Concurrent validity of the BOD POD and dual energy x-ray absorptiometry techniques for assessing body composition in females. *J Am Diet Assoc*. 2002;102:1677-1679.
27. Criee CP, Sorichter S, Smith HJ, et al. Body plethysmography- its principles and clinical use. *Respir Med*. 2011;105:959-971.
28. Stiegler P, Cunliffe, A. The role of diet and exercise for the maintenance of fat-free mass and resting metabolic rate during weight loss. *Sport Medicine*. 2006;36(3):239-262.
29. Hoffman JR. Gatorade Sports Science Exchange. Physiological Demands of American Football. http://www.gssiweb.org/en/Article/sse-143-physiological-demands-of-american-football. 2015;28(143):1-6.
30. Rodriguez NR, Di Marco NM. American College of Sports Medicine position stand. Nutrition and athletic performance. *Med Sci Sports Exerc*. 2009;41(3):709-731.
31. Te Morenga L, Mallard S, Mann, J. Dietary sugars and body weight: systematic review and meta-analyses of randomized controlled trials and cohort studies. *BMJ*. 2012;346:e7492.
32. Kaplan LD, Jost PW, Honkamp N, et al. Incidence and variance of foot and ankle injuries in elite college football players. *Am J Orthop*. 2011;40(1): 40-44.
33. Canale ST, Cantler ED Jr, Sisk TD, et al. A chronicle of injuries of an American intercollegiate football team. *Am J Sports Med*. 1981;9:384-389.
34. Hsu AR, Lareau CR, Anderson RB. Repair of acute superficial deltoid complex avulsion during ankle fracture fixation in National Football League players. *Foot Ankle Int*. 2015;36(11):1272-1278.

35. Colvin AC, Walsh M, Koval KJ, et al. Return to sports following operatively treated ankle fractures. *Foot Ankle Int*. 2009;30(4):292-296.
36. Donley BG, Maschke S, Bergfeld JA, et al. Pronation-external rotation ankle fractures in 3 professional football players. *Am J Orthop.* 2005;34:547-550.
37. Segal D, Wiss DA, Whitelaw GP. Functional bracing and rehabilitation of ankle fractures. *Clin Orthop Relat Res*. 1985;199:39-45.
38. Porter DA, May BD, Berney T. Functional outcome after operative treatment for ankle fractures in young athletes: a retrospective case series. *Foot Ankle Int*. 2008;29:887-894.
39. Thomeé R, Kaplan Y, Kvist J, et al. Muscle strength and hop performance criteria prior to return to sports after ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2011;19(11):1798-1805.
40. Creighton DW, Shrier I, Shultz R, et al. Return-to-play in sport: a decision-based model. *Clin J Sport Med*. 2010;20(5):379-385.
41. Bizzini M, Hancock D, Impellizzeri F. Suggestions from the field for return to sports participation following anterior cruciate ligament reconstruction: soccer. *J Orthop Sports Phys Ther*. 2012;42(4):304-312.
42. Ageberg E, Roos HP, Silbernagel KG, et al. Knee extension and flexion muscle power after anterior cruciate ligament reconstruction with patellar tendon graft or hamstring tendons graft: a cross-sectional comparison 3 years post surgery. *Knee Surg Sports Traumatol Arthrosc*. 2009;17(2):162-169.
43. Augustsson J, Thomeé R, Lindén C, et al. Single-leg hop testing following fatiguing exercise: reliability and biomechanical analysis. *Scand J Med Sci Sports*. 2006;16(2):111-120.
44. Augustsson J, Thomeé R, Karlsson J. Ability of a new hop test to determine functional deficits after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2004;12(5):350-356.
45. Fitzgerald GK, Lephart SM, Hwang JH, et al. Hop tests as predictors of dynamic knee stability. *J Orthop Sports Phys Ther*. 2001;31(10):588-597.
46. Verstegen M, Falsone S, Orr R, et al. Suggestions from the field for return to sports participation following anterior cruciate ligament reconstruction: American football. *J Orthop Sports Phys Ther*. 2012;42(4):337-344.
47. Myer GD, Martin L Jr, Ford KR, et al. No association of time from surgery with functional deficits in athletes after anterior cruciate ligament reconstruction: evidence for objective return-to-sport criteria. *Am J Sports Med.* 2012;40(10):2256-2263.
48. Shulman LM, Pretzer-Aboff I, Anderson KE, et al. Subjective report versus objective measurement of activities of daily living in Parkinson's disease. *Mov Disord.* 2006;21(6):794-799.
49. Mizner R, Petterson S, Clements K, et al. Measuring functional improvement after total knee arthroplasty requires both performance-based and patient-report assessments: a longitudinal analysis of outcomes. *J Arthroplasty*. 2011;26(5):728-737.
50. Stevens-Lapsley JE, Schenkman ML, Dayton MR. Comparison of self-reported knee injury and osteoarthritis outcome score to performance measures in patients after total knee arthroplasty. *PM R*. 2011;3(6):541-549.
51. Heir T, Eide G. Age, body composition, aerobic fitness and health condition as risk factors for musculoskeletal injuries in conscripts. *Scand J Med Sci Sports.* 1996;6:222-227.
52. Watson AW. Ankle sprains in players of the field-games Gaelic football hurling. *J Sports Med Phys Fitness.* 1999;39(1):66-70.